UNITED STATES PATENT APPLICATION

OF

STANLEY PIETROWICZ

And

EVAN FREED

FOR

INTERCONNECTING VOICE-OVER-PACKET AND ANALOG TELEPHONY AT A DESKTOP

INTERCONNECTING VOICE-OVER-PACKET AND ANALOG TELEPHONY
AT A DESKTOP

BACKGROUND OF OUR INVENTION

5   **1. Field of the Invention**

Our invention relates generally to analog and voice over packet telephony. More particularly, our invention relates to customer premise apparatus for conducting and interconnecting analog and voice over packet telephony calls.

10   **2. Description of the Background**

Today's residential and enterprise consumers continue to use the traditional public switched telephone network (PSTN) as the primary way for conducting voice communications. As such, the typical home and enterprise desktops include devices such as analog phones, answering machines, and speakerphones. However, advances in computer technology and the

15   growth of the Internet are making voice communications via packet networks possible (also referred to as voice over packet (VoP)). Under VoP, handsets/headsets/speakerphones along with call control and voice compression technologies are incorporated into the desktop PC to allow consumers to place calls over a packet network, like the Internet. Similarly, emerging service providers are offering commercial-grade voice-over-packet services through the use of dedicated

20   packet-based phones that incorporate network access, call control, and voice compression technologies into a single unit. VoP is becoming increasingly attractive to residential consumers because it provides an inexpensive way to make long-distance calls. Similarly, enterprises, which typically have data networks, are interested in VoP because it provides a way to reduce telecommunication and information technology (IT) costs. However, VoP is far from universal

25   and far from replacing the traditional PSTN. As a result, consumers are faced with a transitional period where both the PSTN and VoP terminate at the desktop. These dual interfaces create several issues, including the need to integrate the PSTN and VoP "worlds" and an increasing amount of equipment on the desktop.

Specifically, today's residential and enterprise consumers typically have multiple PSTN

30   interfaces at the desktop. Because the interfaces are identical technologies, it is well known in the art how to terminate these interfaces in the same device, to manipulate an interface using a single handset, keypad, etc., and to integrate the multiple interfaces to both bridge and transfer calls. However, because VoP and the PSTN are disjoint technologies, they are not easily integrated. Reasons for this difficulty include analog versus digital communications, different methods of

1

call control, differences in delay, noise, and echo sources, and the diversity of interfaces used to access packet networks, including analog access, cable access, LAN access, etc.

Because these technologies are not easily integrated, consumers have an increasing amount of equipment appearing on their desks. This equipment includes the traditional ways of communicating such as analog-based phones/speaker-phones/answering machines, Internet access devices like modems for the PC, and duplicate emerging ways of communicating such as VoP headsets/speakerphones. In addition, consumers have no way to integrate and manipulate the VoP and PSTN interfaces allowing for traditional functionality such as conference calling and the transferring of calls.

SUMMARY OF OUR INVENTION

Accordingly, it is desirable to provide a method and apparatus that integrates traditional analog telephony with VoP telephony at the desktop and reduces the amount of equipment on a consumer's desk, simplifies the management of multiple phones, and allows the analog and packet worlds to be interconnected, thereby overcoming the above and other disadvantages of the prior art. Under our invention, analog and telephony functionalities are integrated into a single desktop appliance, thereby allowing a user to place calls over the PSTN and a packet network. Uniquely, these interactions are made through a single set of user I/O devices (e.g., keypad) and user audio devices (e.g., handset/headset and speakerphone), thereby eliminating duplicate equipment at the desktop, freeing space, and easing the management of multiple interfaces. In addition, the desktop appliance uniquely bridges the PSTN and VoP interfaces, thereby allowing a use to hold, transfer, and conference calls between the PSTN, VoP network, and user audio devices.

In a first embodiment of our invention, the desktop appliance interfaces to both the PSTN and a packet network and as such includes a single set of user I/O and user audio devices, a standard analog interface, analog telephony functionality, a digital interface, and VoP telephony functionality, which includes both VoP call processing and audio compression/decompression. Uniquely, the analog telephony functionality, VoP telephony functionality, and user audio devices are interconnected within the desktop appliance through a digital/analog switching and bridging system. This system, among other features, allows a user to utilize either network interface through the user audio devices, to interconnect the interfaces and audio devices to create various conferencing scenarios, to transfer calls between the two network interfaces, and to bridge the two interfaces, thereby treating the device as a "gateway". Access to the packet network can either be direct (e.g., directly to a LAN), or indirect through the PSTN, a cable provider, etc. In

2

the case of indirect access, the digital interface, as an example, may resemble a standard analog interface with modem functionality.

Because packet networks are able to simultaneously multiplex multiple transactions, the desktop appliance can also support a plurality of VoP calls over the digital interface, in addition to the analog call. Similarly, the appliance can support multiple analog interfaces. Under these two variations of the first embodiment, the switching and bridging system is enhanced to allow interconnectivity among the additional calls.

In a second embodiment of our invention, a desktop PC is integrated with the desktop appliance through a physical connection. This embodiment of the desktop appliance continues to function as the first embodiment with the addition of two enhancements. First, the digital interface within the desktop appliance now provides both the desktop appliance and the desktop PC with access to the packet network, thereby removing the need for a separate PC connection. Second, advanced telephony applications can be provided on the desktop PC to compliment the functionality of the desktop appliance. Specifically, the appliance's analog and VoP telephony functionalities can be controlled and displayed by either the appliance itself or by the desktop PC. In addition, a user audio port on the desktop appliance can be interfaced with the PC to provide enhanced audio functionality.

In a third embodiment of our invention, a desktop PC is again integrated with the desktop appliance, however, the desktop PC now interfaces to the packet network, rather than the desktop appliance, and the appliance uses the PC to gain access to the network. In this embodiment, the VoP voice compression and decompression functionality remains on the appliance; however, the VoP call control is moved to the PC. As such, the desktop appliance continues to handle all speech audio manipulation except for network transmission and reception. The functioning of this embodiment is similar to the first two embodiments, including the continued use of a switching and bridging system to support the interconnectivity of the plurality of interfaces.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a simplified block diagram of a first illustrative embodiment of our invention wherein PSTN and VoP telephony functionality are incorporated into a single desktop appliance and the appliance provides for the interconnectivity of these functionalities.

Figure 2 is a simplified block diagram of a second illustrative embodiment of our invention where the desktop appliance is incorporated with a desktop PC, allowing for the appliance to provide network access for the PC and for the PC to provide advanced telephony applications for the appliance.

Figure 3 is a simplified block diagram of a third embodiment of our invention where the packet network interface functionality and VoP call control functionality are provided by the desktop PC, rather than the desktop appliance.

Figure 4 is an expanded block diagram of the first embodiment of our invention.

5   Figure 5 is a logical connectivity diagram of an illustrative switching and bridging system provided by a desktop appliance in accordance with our invention.

Figure 6 depicts an illustrative block diagram of a back-up power fail system provided by a desktop appliance under our invention.

Figure 7 further depicts the first embodiment of our invention wherein the desktop

10   appliance accesses the packet network through the PSTN and modem interface.

Figure 8 further depicts the first embodiment of our invention wherein the desktop appliance controls multiple simultaneous VoP calls.

Figure 9 further depicts the first embodiment of our invention wherein the desktop appliance provides multiple analog interfaces to the PSTN and supports multiple simultaneous

15   analog calls.

Figure 10 is an expanded block diagram of the second embodiment of our invention.

Figure 11 is an expanded block diagram of the third embodiment of our invention.

DETAILED DESCRIPTION OF OUR INVENTION

20   Figure 1 shows a simplified block diagram of desktop appliance 100, an integrated analog and VoP telephone configuration in accordance with an embodiment of our invention. Unlike the prior art, desktop appliance 100 is a single system containing both analog telephony and VoP telephony components, thereby allowing a user to place calls over PSTN 102 and packet network 104. Uniquely, these interactions are made through a single set of user I/O devices and user audio

25   devices, thereby consolidating the plurality of duplicate equipment present in the prior art into a single device, freeing space and easing management. In addition, desktop appliance 100 uniquely "bridges" the PSTN and VoP interfaces at the desktop, thereby allowing a user to hold, transfer, and conference calls between the PSTN, VoP network, and user audio devices.

The analog side of desktop appliance 100 include analog interface 132, which provides

30   standard access to PSTN 102, and analog telephony processor 134, which provides standard analog call control processing. The VoP half of the appliance includes digital interface 140, which provides access to packet network 104, and VoP telephony processor 138, which provides VoP call control processing and voice compression/decompression protocols as is typically required for packet-based voice communications. Note that digital interface 140 can vary

4

depending on the specific mode used to access the packet network. For example, the digital

interface will provide LAN functionality if the desktop appliance directly interfaces with a packet

network. However, the desktop appliance may also access a packet network via an Internet

Service Provider (ISP) in which case digital interface 140 will provide telephony modem

5   functionality, DSL modem functionality, or cable modem functionality, etc. All audio originating

from the PSTN and packet networks is routed to a switching and bridging system 136 for

subsequent routing within the appliance. Similarly, all audio to be transmitted from the appliance

is first passed through the switching and bridging system and subsequently routed towards the

appropriate network interface.

10   The user I/O devices include hard keypad 124, for entering digits and controlling the

appliance, and LCD display 122, for displaying dialed digits and feature-related call information.

User audio devices include handset/headset 152 (hereinafter handset is used to infer either

handset or headset), speakerphone 154, and audio port 156, the audio port allowing for external

audio device 160, such as an answering machine, to be connected to the appliance.

15   Switching and bridging system 136 implements the unique consolidating and bridging

functionality of the desktop appliance. Specifically, the switching and bridging system, as

described further below, is a multi-port audio system interconnecting and/or bridging the analog

interface, the digital interface, and the user audio devices. The switching functionality

consolidates the user audio devices by allowing any device to be connected to each other or to

20   either network interface. The bridging functionality allows the network interfaces and user audio

devices to be simultaneously interconnected, creating conference type scenarios. The various

types of connectivity are further described below.

              Lastly, application controller 110A provides overall control of the desktop appliance 100.

Specifically, based on user commands entered through the user I/O devices, the application

25   controller configures and controls the PSTN and VoP telephony functionality, the switching and

bridging system, and the user audio devices (control arrow not shown in figure). Similarly, the

application controller relays feature based information received from the PSTN and VoP

interfaces to the user I/O devices for display.

              Figure 2 shows a simplified block diagram of a second embodiment of our invention

30   where desktop appliance 100 is now integrated with a user's desktop PC 112 through physical

connection 116 (e.g., a serial connection(s)). In this embodiment the desktop appliance 100

continues to function as described above in Figure 1 with the addition of two enhancements.

First, digital interface 140 now provides both the desktop appliance 100 and the desktop PC 112

with access to packet network 104. As described above, digital interface 140 can vary depending

on the type of packet network and the way in which this network is accessed. As such, desktop

appliance can provide modem functionality for the PC, as an example. To allow PC-based user -

applications to control and interact with digital interface 140, desktop PC also contains interface

controller 174. For example, if digital interface 140 implements a modem, interface controller

5   174 is a traditional PC-based modem application. Command response processor 170B and host

controller 172B are responsible for transferring data between the digital interface 140 and the

interface controller 174. With respect to the second enhancement, the incorporation of the

desktop PC allows for the development of advanced telephony applications to complement the

functionality of the desktop appliance. In particular, the user I/O devices now also include PC

10   display 126 and telephony application 128B, and the user audio devices now include PC sound

source 158. As such, both the analog and VoP telephony functionality can be controlled and

displayed through any of hard key-pad 124, telephony application 128B, LCD display 122, and

PC display 126. Command response processor 170B and host controller 172B are responsible for

transferring all telephony command and display information between the application controller

15   110B and PC. In addition, user audio devices 152-156 continue to provide an audio interface,

however, audio port 156 can now be interfaced with PC sound source 158 to provide enhanced

audio functionality.

        Figure 3 shows a simplified block diagram of a third embodiment of our invention where

desktop appliance 100, similar to Figure 2, is integrated with a user's desktop PC 112. The

20   operation of this embodiment is similar to that in Figures 1 and 2. However, under this

embodiment, the desktop appliance no longer contains a digital interface for communicating with

the packet network; rather, the desktop PC's digital interface 140C is utilized. In addition, the

VoP telephony processor 138C/138D is now split with VoP call control executing on the desktop

PC and the speech compression and decompression executing on the desktop appliance. As such,

25   the desktop appliance continues to handle all speech audio manipulation except for network

transmission and reception, which are performed by the desktop PC. As with the embodiment

shown in Figure 2, both the analog and VoP telephony functionality can be controlled and

displayed through any of hard key-pad 124, telephony application 128C, LCD display 122, and

PC display 126. Command response processor 170C and host controller 172C are responsible for

30   transferring control/feature information and audio samples between the desktop appliance and

PC. In addition, user audio devices 152-156 continue to provide an audio interface for both

analog and VoP telephony. Uniquely, the continued incorporation of switching and bridging

system 136 within the desktop appliance allows for the consolidation of the plurality of user audio

6

devices present in the prior art and for the conferencing and transferring of calls between the PSTN, VoP network, and user audio devices.

Turning to a detailed description of the above embodiments, Figure 4 shows an expanded

5   block diagram of the first implementation of desktop appliance 100 as described above in Figure 1. As seen in Figure 4, the desktop appliance 100 is implemented through a combination of hardware and firmware modules. The firmware elements are implemented through digital-processor 202, such as Texas Instruments TMS320C5402, using digital signal processing (DSP) technology. Uniquely, under our invention, the analog call control, VoP call control, VoP audio

10   compression/ decompression, the requisite communication protocols, portions of the switching and bridging system, and the inclusion of echo cancellers are all implemented within firmware on a single processor. However, nothing precludes implementing the functional elements shown in Figure 4 as either hardware or firmware, nor implementing the firmware elements across multiple processors.

15   Using Figure 1 as a base reference, analog interface 132 is implemented through digital access 206 and analog front-end 204. Digital interface 140 is implemented through digital front-end 208 and communications protocol controller 210. The analog telephony processor 134 is implemented in the digital domain through firmware elements executing on digital processor 202. These analog firmware elements include analog call processor 222 and analog feature processor

20   220. Similarly, VoP telephony processor 138 is implemented in firmware through three elements including: VoP call processor 226, VoP feature processor 224, and speech compressor and decompressor 228. The switching and bridging system 136 is implemented through a combination of firmware and hardware elements including line echo canceller 230, digital switch and bridge 232, forward echo canceller 240, acoustic echo canceller 234, analog switch and

25   bridge 236, and audio codec 238. User I/O devices, user audio devices, and the application controller 110A are as described above. The following will first describe the functionality of each element in Figure 4 and then describe the interaction of these elements.

Analog front-end 204 provides physical analog access to PSTN 102. Specifically, this element provides line protection, on-hook signal access capability, hybrid functionality, analog

30   power ringing, DC line termination, and line present/high sense functionality. This element can be implemented through discrete analog components, as is known in the art, or through an integrated circuit, such as the SI3044 by Silicon Laboratories.

Digital access element 206 provides digital-to-analog/analog-to-digital conversions. As described above, the analog telephony functionality, including manipulation of the actual analog

audio stream, operates in the digital domain. Digital access element 206 is responsible for converting all analog signals received from the PSTN network to digital pulse code modulation (PCM) signals for processing by the digital processor, and similarly, converting all PCM signals originating from the digital processor to analog signals. The signals processed by digital access

5   206 include: (1) audio signals (voice, music, etc.), (2) feature/Class service parameters originating from the PSTN, (3) call progress signals, ringing signals, and DTMF/dial pulse signals originating from the PSTN, and (4) DTMF and dial pulse signals generated by the user.

Digital access element 206 also performs intermediary functions between the analog front-end and the digital processor, such as reporting the status of analog front end 204 to the

10   processor and configuring the analog front end under the control of the processor. An integrated circuit, such as the SI3044 by Silicon Laboratories, can be used to provide the functionality of digital access element 206.

Digital access to the packet network is provided through a combination of digital front end 208, which provides the physical layers of the OSI stack (e.g., OSI layers 1-2), and

15   communications protocol controller 210, a firmware module that provides the upper layers of the OSI stack (e.g., OSI layers 2-4). Note that the exact form of the digital front end and communications protocol controller depends on the proximity of desktop appliance 100 to the data network as indicated above. For example, enterprise applications of desktop appliance 100 may directly access a LAN, in which case, digital front-end 208 is a standard network interface

20   card and communications protocol controller 210 provides layer 3+ type functionality. However, consumer applications of the desktop appliance, for example, may indirectly access a packet network over a PSTN network. In this latter example, digital front end 208 resembles analog interface 132 and would therefore comprise digital access 206 and analog front-end 204. Here, communications protocol controller 210 would provide telephony and modem functionality (e.g.,

25   ITU V.90, V.34, V.32bis, V.32). Access through the PSTN and a modem is further described below in Figure 5 for clarity.

The user I/O devices, including LCD display 122 and hard keypad 124, and application controller 110A, allow a user to control desktop appliance 100. Specifically, LCD display 122 displays information such as dialed digits and feature service parameters (e.g., calling

30   number/name, time, date, and message waiting indications, received from either network interface). A user controls desktop appliance 100 through hard keypad 124, which includes a DTMF keypad along with hold, speakerphone, conference-call, call-transfer, and mute buttons. These control commands, in addition to line-hold and handset line-use commands, are received by application controller 110A, which subsequently controls and configures analog telephony

processor 134, VoP telephony processor 138, switching and bridging system 136, and the user audio devices (the control lines are not shown in the Figure).

Analog call processor 222 and analog feature processor 220 provide the core analog telephony functionality, including execution of PSTN origination/termination call models and

5   feature processing. Using DSP technology, analog call processor 222 generates and detects signals in order to execute the call models and features. Specifically, based on requests received from application controller 110A as entered by a user via hard key pad 124, the analog call processor generates DTMF or dial-pulse signals for the purpose of dialing and feature interaction. The analog call processor transmits these signals to digital access 206 for conversion to analog

10   signals and subsequent issuing to the PSTN network as described above. Similarly, analog call processor 222 detects and discriminates among DTMF signals, call progress signals (including dial tone, recall dial tone, message waiting indicator tone, audible ringing, line busy tone, reorder tone), and ringing signals (including normal ringing, coded ringing, distinctive ringing, special ringing, and reminder ring) received from the PSTN network. These signals are subsequently

15   reported to the user by generating an audible signal to the speaker phone, as an example.

With respect to feature processing, analog call processor 222 performs Type 1 (i.e., on-hook) and Type 2 (i.e., off-hook) CPE functions for the GR-30-CORE voiceband data transmission interface in order to discern and receive feature-based data. Type 1 functions include the detection of on-hook FSK signals, with and without power ringing, and message

20   parsing. Type 2 functions include detecting and acknowledging the CPE alerting signal (CAS), detecting off-hook FSK, and message parsing. With respect to Type 2 functions, the analog call processor uses the near-end echo canceller 230 to reduce the possibility of near-end talkoff. Once a message is received, analog call processor 222 forwards the message to analog feature processor 220, which extracts the service parameters and presents them to the user (e.g., through LCD

25   display 122). Supported service parameters include date and time, calling number, calling name, visual message waiting indicator, wireless SMS, dialable directory number, call qualifier, calling number reason for absence, and calling name reason for absence.

VoP call processor 226, speech compressor and decompressor 228, and VoP feature processor 224 provide the core VoP telephony functionality. VoP call processor 226 is

30   responsible for call origination/termination using a VoP-based call control protocol such as H.323, SIP, and MGCP. Based on digits/commands received from application controller 110A as entered by the user via hard key-pad 124, VoP call processor 226 formulates and transmits call-processing messages to the packet network via communications protocol controller 210 and digital front-end 208. Similarly, the VoP call processor processes call control messages received

9

from the network. As indicated above, desktop appliance may be indirectly connected to a packet

network, such as through a modem and internet service provider. Under these circumstances,

VoP call processor 226 may also be responsible for establishing the initial connection to the data

network, prior to call processing. (Note that the application software required to establish the

5   initial connection could be situated in the communications protocol controller, VoP telephony

processor, or in an independent element). Finally, VoP call processor 226 passes all feature based

service parameters to VoP feature processor 224 where the information is processed and

presented to the user (e.g., through LCD display 122).

         As is known in the art, digital audio is transmitted over a packet network in a compressed

10   form for efficiency purposes. Speech compressor and decompressor 228 compresses all audio

prior to being transmitted by communications protocol controller 210 to the packet network.

Similarly, this element decompresses all audio received from the packet network prior to that

audio being processed by the digital processor. Speech compressor and decompressor 228 can

utilize various compression/decompression algorithms including ITU G.711, G.723, G.728, and

15   G.729.

         The final components of desktop appliance 100 implement switching and bridging system

136, which, as described above, is a multi-port audio system interconnecting and/or bridging the

PSTN network, the packet network, and the user audio devices. This switching and bridging

occurs both in the analog domain (for the purpose of the user audio devices) through analog

20   switch and bridge 236, and in the digital domain through digital switch and bridge 232. Audio

codec 238 interconnects the digital and analog domains, converting between the analog and PCM

signals emanating from the two networks and the user audio devices. Audio codec 238 can be

implemented through an integrated circuit such as the SI3044 by Silicon Laboratories.

         Analog switch and bridge 236 is a four port analog system that interconnects handset 152,

25   speakerphone 154, audio port 156, and the analog audio stream emanating from digital switch and

bridge 232 through audio codec 238. Under the control of hard keypad 124 and application

controller 110A, the analog switch and bridge 236 provides switching functions (interconnecting

any two points) and bridging functions (bridging any combination of three or more points). The

logical design of analog switch and bridge 236 is further described below.

30   Digital switch and bridge 232 is a three port digital system that interconnects the audio

stream from the PSTN network, the audio stream from the VoP network, and the digital audio

stream emanating from analog switch and bridge 236 through audio codec 238. Under the control

of hard keypad 124 and application controller 110A, the digital switch and bridge provides

switching functions (interconnecting any two points) and bridging functions (bridging all three points). The logical design of digital switch and bridge 232 is further described below.

Line echo canceller 230, acoustic echo canceller 234, and forward echo canceller 240 are adaptive echo cancellers (Note that these three echo cancellers are highly desirable but are not

5   required to implement switching and bridging system 136 nor the desktop appliance in general.) Line echo canceller 230 removes echo produced by the near end hybrid situated in analog interface 132 and produced by the PSTN network. Forward echo canceller 240 is operative when the desktop appliance is interfaced to a far-end speakerphone via the packet network. In this case, the forward echo canceller removes residual echo produced by the far-end speakerphone.

10   Acoustic echo canceller 234 is operative when speakerphone 154 is employed. This echo canceller allows the speakerphone to operate in full duplex mode for PSTN and packet network audio transactions by removing speaker phone induced acoustic echo.

Figure 5 shows a logical connectivity diagram of switching and bridging system 126, where Ds1-Ds6 represent digital switches, As1-As10 represent analog switches, Db1-Db6

15   represent digital adders, and Ab1-Ab6 represent analog adders. Table 1 shows the combinations of switching and conferencing connectivity that can be achieved through the system: column one showing the connectivity combinations, column two showing the digital and analog switch closures needed to accomplish each combination, and column three indicating whether line echo canceller 230, acoustic echo canceller 234, and/or forward echo canceller 240 are utilized in the

20   given combination (note that the forward echo canceller is only employed if there is a far-end speaker phone being used). For example, any of the user audio devices can be connected to a single network. Similarly, both networks and any user audio device can be bridged to establish a conference call. In addition, the desktop appliance can act as a gateway, simply bridging the PSTN and packet networks.

25

11

Table 1. Desktop Appliance Connectivity Chart

Type of Connectivity	Switch Closures (Default open)	Type of Echo Cancellation Utilized
Single Two Way Connectivity		
PSTN Network & Handset	Ds1, Ds2, As3, As4	Line Echo Canceller
PSTN Network & Speakerphone	Ds1, Ds2, As5, As6	Line Echo Canceller & Acoustic Echo Canceller
PSTN Network & Audio Port	Ds1, Ds2, As1, As2	Line Echo Canceller
Packet Network & Handset	Ds3, Ds4, As3, As4	Forward Echo Canceller
Packet Network & Speakerphone	Ds3, Ds4, As5, As6	Acoustic Echo Canceller & Forward Echo Canceller
Packet Network & Audio Port	Ds3, Ds4, As1, As2	Acoustic Echo Canceller & Forward Echo Canceller
Audio Port & Handset	As9, As10	None
Audio Port & Speakerphone	As7, As8	None
PSTN Network & Packet Network	Ds5, Ds6	Line Echo Canceller & Forward Echo Canceller
Single Three Way Connectivity		
PSTN Network, Packet Network, & Speakerphone	Ds1, Ds2, Ds3, Ds4, Ds5, Ds6, As5, As6	Line Echo Canceller, Acoustic Echo Canceller, & Forward Echo Canceller
PSTN Network, Packet Network, & Handset	Ds1, Ds2, Ds3, Ds4, Ds5, D6, As3, As4	Line Echo Canceller & Forward Echo Canceller
PSTN Network, Packet Network, & Audio Port	Ds1, Ds2, Ds3, Ds4, Ds5, Ds6, As1, As2	Line Echo Canceller & Forward Echo Canceller
PSTN Network, Audio Port, & Handset	Ds1, Ds2, As1, As2, As3, As4, As9, As10	Line Echo Canceller
PSTN Network, Audio Port, & Speakerphone	Ds1, Ds2, As1, As2, As5, As6, As7, As8	Line Echo Canceller & Acoustic Echo Canceller
Packet Network, Audio Port, & Handset	Ds3, Ds4, As1, As2, As3, As4, As9, As10	Forward Echo Canceller
Packet Network, Audio Port, & Speakerphone	Ds3, Ds4, As1, As2, As5, As6, As7, As8	Acoustic Echo Canceller & Forward Echo Canceller
Single Four Way Connectivity		
PSTN Network, Packet Network, Audio Port, & Handset	Ds1, Ds2, Ds3, Ds4, Ds5, Ds6, As1, As2, As3, As4, As9, As10,	Line Echo Canceller & Forward Echo Canceller
PSTN Network, Packet Network, Audio Port, & Speakerphone	Ds1, Ds2, Ds3, Ds4, Ds5, Ds6, As1, As2, As5, As6, As7, As8	Acoustic Echo Canceller, Line Echo Canceller, & Forward Echo Canceller
Dual Two Way Connectivity		
(PSTN Network & Handset) <u>and</u> (Audio Port & Speakerphone)	(Ds1, Ds2, As3, As4) <u>and</u> (As7, As8)	Line Echo Canceller
(PSTN Network & Speakerphone) <u>and</u> (Audio Port & Handset)	(Ds1, Ds2, As5, As6) <u>and</u> (As9, As10)	Line Echo Canceller & Acoustic Echo Canceller
(Packet Network & Handset) <u>and</u> (Audio Port & Speakerphone)	(Ds3, Ds4, As3, As4) <u>and</u> (As7, As8)	Line Echo Canceller & Forward Echo Canceller
(Packet Network & Speakerphone) <u>and</u>	(Ds3, Ds4, As5, As6) <u>and</u>	Acoustic Echo Canceller &

(Audio Port & Handset)	(As9, As10)	Forward Echo Canceller
(PSTN Network & Packet Network) and (Audio Port & Handset)	(Ds5, Ds6) and (As9, As10)	Line Echo Canceller & Forward Echo Canceller
(PSTN Network & Packet Network) and (Audio Port & Speakerphone)	(Ds5, Ds6) and (As7, As8)	Line Echo Canceller & Forward Echo Canceller
Dual Two & Three Way Connectivity		
(PSTN Network, Packet Network, & Handset) and (Audio Port & Speakerphone)	(Ds1, Ds2, Ds3, Ds4, Ds5, Ds6, As3, As4) and (As7, As8)	Line Echo Canceller & Forward Echo Canceller
(PSTN Network, Packet Network, & Speakerphone) and (Audio Port & Handset)	(Ds1, Ds2, Ds3, Ds4, Ds5, Ds6, As3, As4) and (As9, As10)	Line Echo Canceller, Acoustic Echo Canceller, & Forward Echo Canceller

Desktop appliance 100 typically requires AC power in order to function and therefore becomes inoperative if power is lost. The loss of basic telephony functionality is addressed through a "back-up power fail system" as shown in Figure 6 (Figure 6 is a simplified version of

5   Figure 4, showing only the elements needed to implement the back-up power fail system). Specifically, if power is lost, power-up switch 402 connects the PSTN analog interface, and the corresponding analog line-power, to analog phone 404, which provides basic telephony functionality. The implementation of analog phone 404 is known in the art. The analog phone also includes an independent keypad controller 406a, interfaced to hard key-pad 124 for control,

10   and an independent ringer 406b. Human interface to analog phone 404 is provided through handset 152 or optionally, speakerphone 154.

As mentioned above, desktop appliance 100 as described in Figure 4, can indirectly access the packet network over the PSTN network through a modem. Figure 7 shows an even

15   more detailed functional drawing of this embodiment. As shown, the digital interface 140 now resembles the analog interface described above. Specifically, analog front-end 204B, digital access 206B, and analog call processor 222B provide dial-in access to the PSTN network and, as an example, an ISP's modem pool. Communications protocol controller 210B provides the required modem functionality (e.g., ITU V.90, V.34, V.32bis, V.32), including a line echo

20   canceller to deal with echo produced by the PSTN and near end hybrid, and the upper layers of the OSI stack. If necessary, application software required to communicate with an ISP can be situated in the communications protocol controller, VoP Telephony Processor, or through an independent element. Besides the addition of the analog interface, the desktop appliance continues to function as described above with respect to the VoP and analog telephony

25   functionality, and the switching and bridging functionality as described in Figure 5 and Table 1.

However, because the appliance now contains a second PSTN interface, a user can
bypass the VoP telephony functionality and communications protocol controller and treat
interface 140 not as a digital data interface, but rather as a standard analog interface providing
access to PSTN 102 as described above for the first analog interface. As such, desktop appliance
5   100, under this embodiment, has two modes – the first mode being a two-line phone with one
interface being VoP and the second interface being analog, and the second mode being a two-line
analog phone (the two modes being controlled by application controller 242). When the second
PSTN interface is used for voice calls, line echo canceller 230B is employed, similar to line echo
canceller 230, and forward echo canceller 240 is disabled. The unique connectivity functionality
10   also holds for this embodiment and is similar to Figure 5 and Table 1 (e.g., the forward echo
canceller 240 is replaced with line echo canceller 230A, etc. in Figure 5, and PSTN network
replaces packet network in Table 1).

Because a packet network simultaneously multiplexes multiple transactions, desktop
15   appliance 100 as described above in Figures 4 and 7 can also be expanded to support multiple
VoP calls. This embodiment is shown in Figure 8. Under this embodiment, multiple VoP audio
streams are controlled (originated and terminated) by VoP call processor 226C and VoP feature
processor 224C, and by hard keypad 124 and application controller 244. Each audio stream is
transmitted and received through digital front end 208 and communications protocol controller
20   210C, compressed/decompressed by speech compressor and decompressor 228C, and passed
through switching and bridging system 136. However, digital switch and bridge 232C must be
enhanced to support interconnectivity amongst the plurality of VoP audio streams, the PSTN
interface, and the user audio devices (similarly, the forward echo canceller 240C must be
enhanced). Such an enhancement is an extrapolation of Figure 5 and Table 1. Hence, as an
25   example, desktop appliance 100 can connect any one of the VoP audio streams to a user audio
device, conference multiple VoP streams with the PSTN network and a user audio device, and act
as a gateway to bridge multiple VoP calls. Also note that digital interface 140 can be an analog
interface as described in Figure 7, providing both an analog phone mode and a modem mode,
with the modem mode supporting the multiple VoP calls.

30
In addition to the single digital interface 140 and the single analog interface 132 (as
described in Figures 4, 7, and 8) desktop appliance 100 can also be expanded to support a
plurality of analog interfaces to the PSTN as shown in Figure 9. Under this embodiment,
multiple analog interfaces 132D must be physically added to the appliance. Similarly, application

controller 246, analog call processor 222D, analog feature processor 220D, line echo canceller

230D, and digital switch and bridge 232D must be enhanced to support the additional interfaces.

(Again, Figure 5 and Table 1 can be extrapolated for this embodiment). Note also that the

functionality of desktop appliance 100 as described in the Figure 8 embodiment can be combined

5   with the functionality as described in this Figure 9 embodiment.

        Figure 10 is an expanded block diagram of the implementation of desktop appliance 100

as described in Figure 2. Desktop appliance 100 continues to function as described above,

however, the appliance is now also integrated with desktop PC 112. Under this embodiment,

10   desktop appliance 100 provides the desktop PC with access to the packet network and the desktop

PC provides the desktop appliance with advanced telephony applications.

        Desktop appliance 100 and desktop PC 112 are interconnected through a physical

interface 116, command response processor 170B, and host controller 172B. Physical interface

116 can be, for example, one or more serial interface connections. Command response processor

15   170B and host controller 172B are driver type modules that coordinate communications between

the two systems. Through this interconnection and the interface controller 174 (which is an

interface driver for digital interface 140) generic applications residing on desktop PC are able to

interface with digital interface 140 and establish communications with the packet network. As a

result, desktop appliance appears, for example, as a modem to desktop PC 112. In addition, the

20   interconnection of the two systems, in conjunction with PC display 124 and telephony application

128B, provides an alternate way to control the analog and VoP telephony functionality and to

display related call information.

        In addition, audio port 156 can be connected to the desktop PC's PC sound source 158

through a serial port, for example. This interconnection allows for the development of additional

25   PC-based applications, such as an answering machine.

        The logical connectivity diagram of switching and bridging system 120 shown in Figure

5 and the corresponding connectivity combinations shown in Table 1 also hold for this second

embodiment. In addition, the back-up power fail system as shown in Figure 6 also holds for this

embodiment. Lastly, the functionality described in the Figures 7-9 embodiments can be similarly

30   applied to this embodiment.

        Figure 11 is an expanded block diagram of the implementation of desktop appliance 100

as described in Figure 3. Desktop appliance 100 continues to function as described above.

However, under this embodiment, the desktop appliance no longer directly interfaces to the

packet network. This functionality is provided through the desktop PC. In addition, the VoP telephony functionality is now split with VoP feature processor 310 and VoP call processor 312 executing on the desktop PC and the speech compressor and decompressor continuing to execute on the desktop appliance.

5   Under this configuration, a user can continue to control and display both the analog and VoP telephony functionality through hard-key-pad 124, telephony application 128C, LCD display 122, and PC display 124. In addition, all analog and VoP user audio interactions are through the user audio devices as above. The difference, as compared to the above embodiments, is that the VoP call processing executes on the PC and all audio transmitted and received by the desktop

10   appliance pass through the PC's digital interface 140C, host controller 172C, physical interface 116, and command response processor 170C.

Uniquely, all audio continues to pass through switching and bridging system 136, which allows the audio devices, packet network, and PSTN network to be interconnected. The logical connectivity diagram of switching and bridging system 136 and the corresponding connectivity

15   combinations are the same as shown in Figure 5 and Table 1. In addition, back-up power fail system as shown in Figure 6 also holds for this embodiment. Lastly, the functionality described in the Figures 8 and 9 embodiments can be similarly applied to this embodiment. In particular, with respect to multiple VoP telephony audio streams, the desktop PC would provide the call control and the desktop appliance would provide speech compression/decompression and the

20   interconnectivity of the streams amongst each other, the PSTN network, and the user audio devices.

The above-described embodiments of our invention are intended to be illustrative only. Numerous other embodiments may be devised by those skilled in the art without departing from

25   the spirit and scope of our invention.